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FARWAGI 7348

Storage is one of the fastest moving areas in the PC industry. Here, we present a round-up of the latest developments . . .

Sony ends the long wait

The long wait for an erasable optical disk drive may be over in October, when Sony ships sample units of its magneto optical disk drive systems.

Sony will introduce a 51/4in magneto optical drive that stores 325Mbytes of data on each side of a removable cartridge, according to Dr Yoshio Aoki, director of technology at Sony's Advanced Technology Group.

The company will ramp up to full production in early 1988.

The new drive is geared primarily toward the OEM market, but Sony is also courting end users, especially in the military and government, Dr Aoki said.

Pricing in American currency has not been set, but users can plan to pay nearly 1 million yen for the drive (roughly, $10,000 at today's exchange rates). The removable cartridges will cost about 30,000 yen ($300).

According to Dr Aoki, erasable optical disk drives combine the capacity and reliability of laser optical systems with the flexibility of erasable magnetic media.

The new drives will revolutionise optical storage, industry analysts said, allowing users to store data and change it as they would with a hard disk.

For instance, Sony's drive will allow users to store up to 650M bytes of data on the cartridge and update or change it. The removable cartridge could then be ported from drive to drive or locked in a safe for secure applications, Dr Aoki said.

Erasable media breathes a fresh life into the optical market, which currently features products that prevent users from writing over original data. Last year's world wide installed base of Write Once Read Mostly (WORM) disk drives — 3200 units — is an indication of the drives' limitations, according to Bob Gaskin, an analyst with Dataquest.

Sony has been developing erasable media since 1983, when it announced an agreement with KDD (Japan's international telephone and telegraph company) to make a 12in magneto optical system, which KDD now uses in its operations.

Last year, Sony and three other companies — Alcatel Thomson Gigadisc, of France; Optical Storage International, of Santa Clara, California; and Philips and Dupont Optical Co., of the Netherlands — announced agreement on the basic specifications for 51/4in disk drives and media.

Tandon removable hard disk

After making a thunderous charge into the PC-compatibles market last year, Tandon has realigned its PC product line around a new removable hard-disk drive.

The removable drive, called the Personal Data Pac, came out last month. Tandon has incorporated the drive into a new AT compatible as well as an external unit that connects to IBM PCs and compatibles. Tandon will use the Personal Data Pac to differentiate its AT- compatible, the Targa, from a crowded pack of competitors. Furthermore, the company is betting it can sell the removable drives on the mass-storage market, while also licensing its technology to other manufacturers.

However, industry experts said Tandon faces the formidable challenge of convincing users that moving a hard disk from place to place is safe and productive. "My own impression is that it is a solution that will appeal to a limited audience, namely those who have to move a large database from place to place," said Bob Katzive, vice president of Disk/Trend, a disk- drive consulting firm.

Tandon officials tout the Personal Data Pac as a method for users to port their applications and data from PC to PC. The firm also stresses the security advantages of the disk drives because they can be removed and locked up. And, some observers noted, the $US350 Personal Data Pac is a less expensive method of backing up data than copying data onto 20Mbyte tape drives, which cost between $1200 and $3000.

The Australian distributor of Tandon products, Adaptive Electronics, has not yet finalised pricing of the Data Pac but the following could be considered reasonable

While we wait for its erasable optical disk, Sony is offering a CD-ROM for the IBM PC estimates: The Personal Data Pac consists of a 30Mbyte hard disk drive encased in a hard plastic cartridge about the size of a thick paperback book. Tandon officials said the drive is mounted so that it can be dropped and still operate. The one kilogram drive should cost around $700 and has an average access time of 40 milliseconds, the same as the fastest disk drive IBM sells for its AT.

Tandon has also redesigned its small footprint AT-compatible Targa to contain two receptacles for the removable hard drives. The PAC 286, which includes circuitry that allows applications supporting the Lotus/Intel/Microsoft Expanded Memory Specification to access memory above 640k bytes, will be shipped in May.

To bring its removable drive to other PCs, Tandon also introduced the Ad-PAC2, an external unit that holds two Personal Data Pacs. The Ad-PAC2 should around $1200.

IBM debuts WORM optical drives

IBM last month entered the optical storage arena with the introduction of two 200Mbyte Write Once/Read Mostly (WORM) optical disk drives.

The drives are among the computing 'options' IBM introduced last month to enhance its new Personal System. They will be available shortly for $US2950, IBM said. While the unit has been announced in Australia, no price has yet been set.

Aimed primarily at corporations with large databases and archiving needs, the drives are similar to existing optical storage products but provide only 200Mbytes of storage. Most WORM drives store 400Mbytes, while CD ROM disk drives store up to 550Mbytes.

However, over a gigabyte of storage can be achieved by configuring eight IBM WORM drives together, company officials noted. This configuration, known as daisy-chaining, is achieved by installing four adaptor boards in a computer and connecting two drives to each adaptor, an IBM spokesman said. That configuration produces the maximum 1.6 gigabytes of online storage. Despite that potential capacity, the drives are not suited to every user's needs, according to Jim Porter, a disk- drive analyst and publisher of Disk Trend Report.

The specialised applications that IBM is addressing with its new drive — storage of large personnel files, technical manuals and audit information — do not resemble the usage patterns of most people, Mr Porter said.

"The most popular PC function, word processing, is constantly subject to modification, something you can't do on a write-once disk," he said.

However, users with specialised applications now have the option of moving into the budding field of optical storage with the confidence inspired by IBM, he added.

The 5¼in external drives, made by Matsushita of Japan, include IBM developed software that allows users to access the 200Mbytes as a single DOS volume, the way a hard disk would. The drives also feature a front loading cartridge for easy portability and storage.

One model, the A01, is compatible with existing PCs and the new Personal System/2 Model 30. It will be available this quarter, an IBM spokesman said. The second model, called A11, is designed for use with IBM's new Models 50, 60 and 80, which are based on the 80286 and 80386 chip. It will ship, along with the other new computers, in the third quarter.

IBM officials said an external drive without an adaptor card, designed to provide extra storage through daisy-chaining, will be available in the second quarter.

An internal 5¼in optical drive, priced at $US2700 and designed for the high end Models 60 and 80, will be available in the fourth quarter.

Moving to 3.5in format

IBM revealed four options last month designed to bridge the gap between 5¼in floppy disk drives and the new 3.5in format of its new Personal System/2 series of microcomputers.

The first option is a $316, 3.5in internal floppy drive that can be installed in five of IBM's PC XTs (models 88, 89, 267, 278 and 286) and two of IBM's PC ATs (models 319 and 339).

The second option is a $810, external 3.5in drive, also available for the IBM XT and AT models.

The third device is IBM's $75 Data Migration Kit, which allows users of IBM PCs, XTs or ATs to transfer data to computers in the Personal System/2 line via serial connection.

The kit requires a standard IBM printer cable to connect the two parallel ports in either machine.

Finally, IBM next month will ship a $996, 5¼in external disk drive that enables Personal System/2 microcomputers to run data stored on 5¼in floppies.

Lotus has already shipped a 3.5in version of Lotus Express and plans to release the reduced size version of 1-2-3, Symphony and Freelance Plus this month. HAL, Lotus Manuscript and Metro will be available in the 3.5in format by December, a Lotus spokesman said.

Ashton-Tate will market 3.5in versions of its major software programs in a 'Premium Pack,' which will also include 5¼ inch versions of the programs, a company official said.

With major software manufacturers backing the new format, the transition from 5¼in to 3.5in floppy drives will be gradual, but definite, according to industry analysts.

The 3.5in format, first embraced by IBM in its PC Convertible, provides greater storage capacity than 5¼in disks, and is technically a better solution for data saving and portability.

"At some point, IBM had to bite the technical bullet and jump to the 3.5in format," said Jim Stone, an analyst with Shearson Lehman Bros. "The intent for the whole package is to regain market share and maintain account control."

51/4in disk offers 3.2Mbytes

Maxell last month unwrapped a new 5¼in floppy disk that offers 3.2Mbytes of storage.

Designated as MD2-ED, the new floppy disk responds to user demand for higher capacity media, according to Maxell officials.

The disk, which is compatible with the new YD-801 disk drive developed by Y-E Data of Tokyo, will become available later this year.

The MD2-ED's price has not been set.

Meanwhile, 3.5in floppy disk drives from Maxell and other companies are already proving a fierce competitor to the 5¼ inch disk, company officials said.

Data transfer, using the MD2-ED disk and the Y-E Data Drive, is rated at 500k bits per second, Maxell officials said.

After formatting, the disk can store 2.4Mbytes, a significant increase over the 320k capacity of standard 5¼in disks.

The new floppy disk uses magnetic particles applied to the disk surface at about one micron of thickness to increase the floppy's storage capacity.

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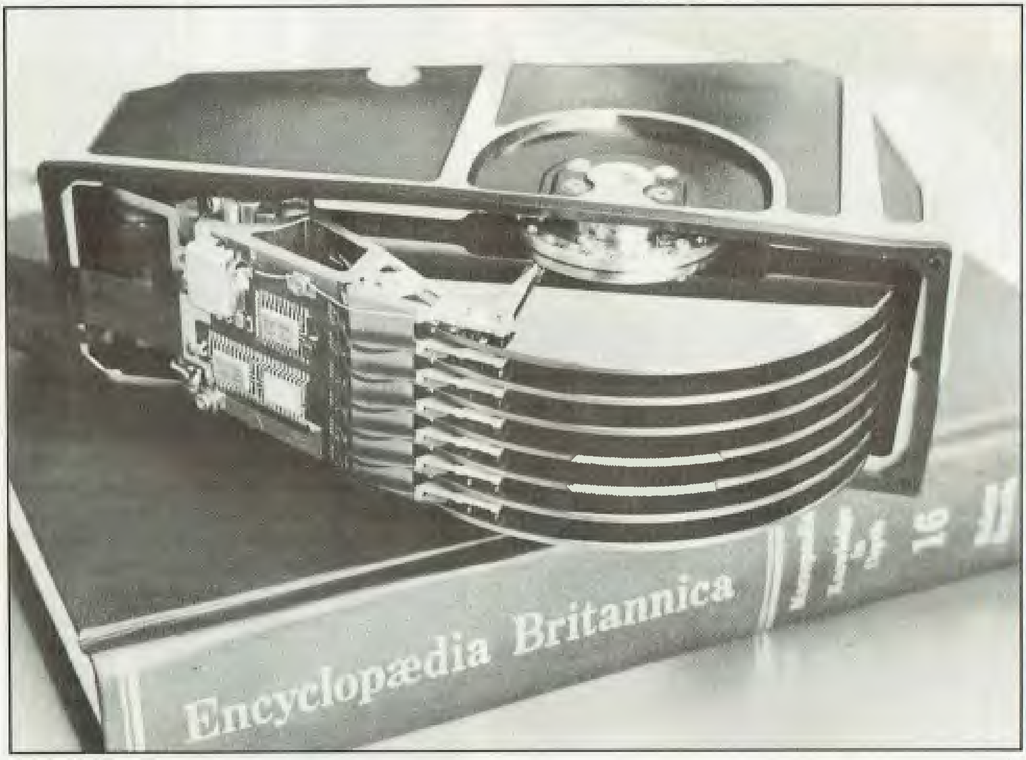

Another product to consider while we wait for erasable optical disks — Siemans 700Mbyte MegaFile

to users as soon as the Y-E Data drives make their way into this market.

Verbatim's 50Mbyte in a pocket

A 3.5in erasable optical disk drive that enables users to walk away from their PCs with a 50Mbyte file tucked inside a pocket is off the drawing boards and on the factory shelves at Verbatim.

The drive, which was shown at Comdex/Fall last November, is scheduled for introduction by mid 1988, according to Fred Geyer, general manager of Verbatim's Magneto Optic Drive and Media Division.

The drive cartridge is about two and a half times the thickness of a floppy disk drive and will be able to store 50Mbytes to 100Mbytes of data, according to Mr Geyer.

Users will be able to load and remove the drive cartridge as they would a floppy disk drive.

Not only will the drive provide portability of large databases that are now stored on fixed disks, but it will rival tape as a primary means of backup, according to Mr Geyer.

The ease with which the product dumps huge files onto a drive with a single DOS command will challenge even the most advanced tape backup units, according to Mr Geyer.

Pricing for the unit has not been determined. However, said Mr Geyer, the drive will probably cost 50 per cent more than disk drives of the same capacity.

The disks will be inexpensive, priced at about $1 per megabyte.

Verbatim began showing its new technology in 1985, and has since refined the product according to user response.

"The drive currently has an access speed of 70 milliseconds (ms), but that figure could accelerate to 30ms by the time the drive is introduced next year," Geyer said. Recent figures quoted by Verbatim officials indicate that an 80Mbyte drive with an access speed of 30ms is a reasonable expectation.

But even an 80Mbyte drive is not outstanding in the optical arena, where Write Once/Read Mostly (WORM) drives store 200M bytes per side and Compact Disk, Read Only Memory (CD ROM) drives hold 550Mbytes.

WORM and CD ROM drives, however, cannot be erased.

"Kodak, of which Verbatim is a subsidiary, always plays conservatively when introducing a new technology," explained Ed Rothchild, publisher of Optical Memory News, an industry newsletter.

Mr Rothchild also said the Verbatim product will spur development of other erasable optical drives with higher capacities.

Competitors in the optical drive market are looking forward to the Verbatim entry with interest.

"[The new drive] will broaden the market for all of us," said a competitor who asked not to be identified. "Regardless of the capacity of this drive, they've done their job by getting erasable [drives] onto the desktop," he said.

Rodime says firms violate its 3.5in patents

In a move greeted with scepticism in the disk drive industry, Rodime plc. has gone to court claiming it has the sole patent on 3.5in hard disk drives.

In suits filed against Miniscribe Corp, and Conner Peripherals Inc., of San Jose, California, Scotland-based Rodime claims both firms violate patents it holds on the technology for the 3.5in Winchester disk drive.

Rodime's patent claims are based on the fact that it was the first, in 1983, to make a 3.5in disk drive. It seeks unspecified royalties and lost profits, and an injunction against the sale of drives that infringe on the patents that the manufacturer has not licensed.

Besides the suits, neither of which has yet come to trial, Rodime has contacted approximately 20 disk drive firms asking them to enter such licensing agreements.

Several competitors and industry observers said it appears Rodime is trying to patent the 3.5in 'form factor,' or size, rather than any new technology.

"Form factor patents are tough," said Carter O'Brien, marketing director for rival drive maker Seagate Technology. "If that were true, the Japanese wouldn't let Americans build small cars."

US District Court Judge John Kane in Denver has ordered both Rodime and Miniscribe to explore a pretrial settlement, but to date only preliminary discussions have been held, according to a Rodime attorney.

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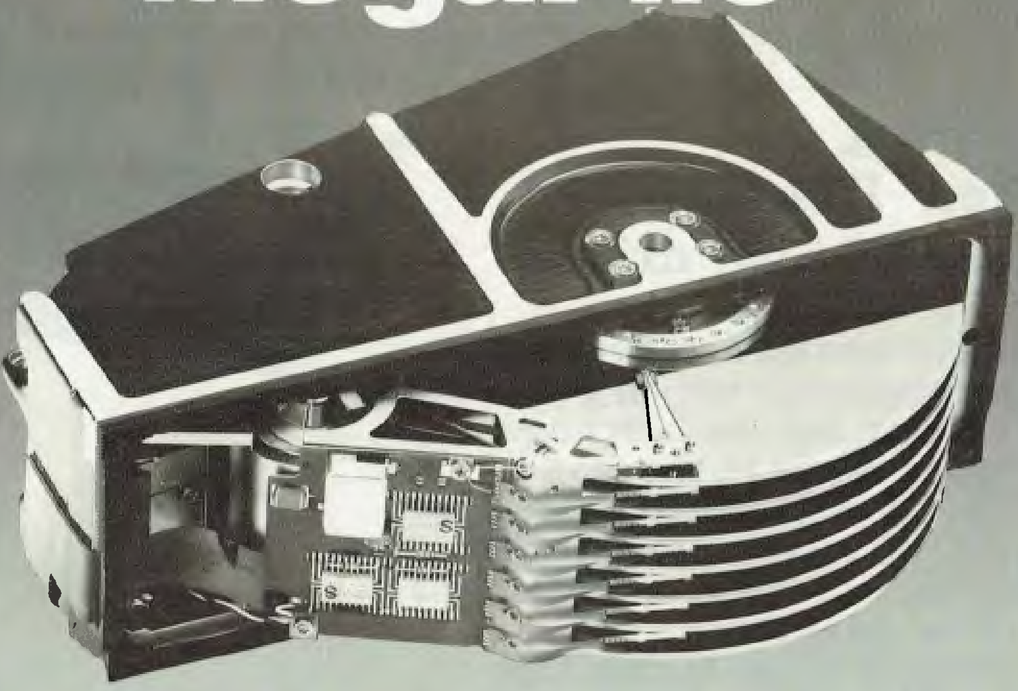

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CONTROL DATA

Bernoulli Box v Diskit-2

Ian Davies presents an in-depth assessment of the two leading removable hard disk systems. But firstly, who'd want a removable hard disk system anyhow? Read on . . .

The state of magnetic media is pretty much as it has been for the last ten years. On the one hand, we have low capacity, low speed floppies with the advantage of massive offline storage, transportability and backup suitability. On the other hand, we have hard disks with their rapid access speed, high capacity and dangerous fragility which are often used as a basket into which one may put all of one's eggs.

Each technology has its own advantages and disadvantages, and in many ways complement each other well. Yet hard disks remain unacceptably sensitive to shock and floppies provide a simply inadequate means of backup. Streaming tape devices are employed by many users as a suitable backup mechanism, as they provide high capacity, reasonable speed and removability. However, a streaming tape is rather expensive given its inability to be used as anything other than a backup device.

However, several manufacturers have attempted to combine the best attributes of both floppies and winchesters by creating removable hard disks. These provide high capacity, relatively high speed, removability for infinite offline storage and a high degree of transportability.

Although removable hard disks are far from new, the two units examined here both provide dual drives, thereby solving backup problems.

By utilising two drive mechanisms, the user is presented with a consistent and regular environment. The drives function as dual disks during every day use, but one can be backed up onto a blank disk placed in the other drive. Moreover, the backup is not on a physically and conceptually different media, but is exactly the same as the original. Indeed, there is little need for a restore facility, as restoration could be as simple as ejecting the corrupted master and inserting the backup. In real life, of course, normally only portions of a disk become corrupt, and so partial restores are still desirable.

Additionally, since both the master and backup devices are normal DOS disk volumes, backups can be done using normal MS-DOS commands — further simplifying the user interface. This has to be good news for anyone who has battled with the DOS BACKUP and RESTORE commands, particularly across different versions or OEM implementations of DOS where the backup volumes may be numbered in incompatible manners, or where one needs to RESTORE into a different subdirectory. Although not really necessary, both of the products reviewed here provide their own backup and restore utilities.

Backups are a subject most users find difficult to approach with any degree of excitement, yet should be the most important part of computer usage. Many users do not realise that disks can, and do, become corrupt at any time. Usually the likelihood of a corruption increases with the time since the last backup (and of course the importance of the data, and difficulty in recreation). Sadly, however, many users do not fully appreciate the importance until they really need it. Then, of course, it is too late.

Everyone is guilty of insufficient backups, but the main cause of the problem is the lack of a suitable media. Users for whom the prospect of a 50 floppy backup makes it a monthly event might find themselves performing daily backups if the process could be shortened to five or ten minutes of unattended operation.

But removable hard disks offer more than just the advantages of painless backups. Many PC applications are becoming increasingly security critical, and busy executives find it far more interesting to worry about industrial espionage than lightning bolts.

Several security packages exist for PCs, and some machines come with password protection built into the BIOS

ROM. Most password protection schemes are like household locks — they keep out the honest people and make the owner feel better, but offer no real protection against the determined professional. Some systems are so trivial that they can be bypassed by booting from a floppy. Others might require a little hardware knowledge. Of course, anything can be broken. Even the highly regarded DES system can be beaten using powerful supercomputers.

Then there is the other type of security risk. While many people might like to copy your data in an undetected fashion, several will make do with stealing the entire machine — crypto board and all. Again, desk locks and PC bonders are available to reduce the risks.

Finally, there is the security risk few users think about. The disgruntled employee or trespassing competitor may not have the skill to break the security, nor the support to remove the entire machine, but they almost certainly have the time and ability to put an axe through the machine, or pour a glass of beer through the disk drive. The story comes to mind of the Melbourne ATM (Automatic Teller) which was protected up to the hilt by PIN codes, encrypted data lines, withdrawal limits and all sorts of high-tech goodies. The ATM had its security compromised by a man with a forklift truck who simply scooped the thing out of the front of the bank and made off with it. Probably not a contingency planned for by the computer security consultants.

It comes down to the fact that the best type of security is physical security. If the data is really important, put it under lock and key in a safe. No spotty 15 year old with a Cray XM-P will be able to touch it, and everybody else probably won't even expect it to be there.

Thus removable hard disks also offer extremely good security at very low inconvenience.

The two units reviewed here both provide dual removable disks mounted in an external casing. They both offer all of the advantages inherent in the concept. Yet they remain quite different products, even based upon different technology and with very different attractions to prospective purchasers.

IDEAssociates Diskit-2

The Diskit-2 employs normal rigid disk platters in a removable cartridge a little smaller than a normal floppy disk but about a centimeter thick. The unit itself is a slim 56 x 330 x 386 mm, designed to sit under the monitor and shaded an inconspicuous IBM grey. The Diskit-2 provides 10Mbytes of half height accommodation in each drive, and weighs in at a reasonable 8kg.

The cartridges are 107 x 107 x 12 mm and weigh a paltry 140g. This makes them easy carrying either thrown into a briefcase or slipped into a large pocket. The cartridge case is of plastic construction with a large metal hub, and features a surface protector similar to those used on the new 3.5in format. The protector slides back automatically upon insertion and closes upon removal. The slide can also be retracted manually to expose the metallic gold of the disk surface. Manual retraction is far from recommended, as ones fingers tend to slip as the cover shifts with a jerk and would easily result in a fingerprinted disk surface.

> *'What happens if a whole bunch of writes are sitting in the cache when the user changes disks? Presto — two corrupt disks for the price of one!'*

A read/write protect tag is located on the opposite end of the cartridge. Most removable hard disk systems feature write protect tags to guard against accidental damage to an important backup. The tag takes the form of a small clip with must be removed to enable write operations. The tag is easily clipped to the disk, but takes a small amount of persuasion to remove.

The most disconcerting aspect of these cartridges is that they rattle when shaken. The platter and hub have sufficient play to move in five degrees of freedom in addition to the normal one of rotation. Sometimes the very edge of the surface comes into contact with the cartridge casing. It's disconcerting, but it should not be a concern, however, as the outermost edge of the platter is not used for data recording purposes.

Each cartridge contains a single platter soft sectored disk holding 741 tracks per inch. The sector interleave factor is set at 1, which means that the device is probably going to give superior performance on faster machines. A total of 10.6Mbytes of storage is distributed across 610 cylinders, accessed by a predictable two read/write heads. Effectively, the cartridge is a normal hard disk platter housed in a plastic casing.

The Diskit-2 unit itself features a power switch and power indicator LED on the front panel accompanied by the dual disk slots. Each slot has what appears to be a three colour LED used to indicate ready, access and error. A button on the slot releases an access flap which must then be dragged back to 90 degrees using an alarming amount of force. The amount of force required is probably perceived rather than actual, as one simply expects such a delicate mechanism to be handled with extreme care and much gentle sliding of well oiled components. The fact that the access flap needs some gentle persuasion is probably an indication that the unit can withstand reasonable treatment.

Pressing the release button while the drive is in use causes the LED to flash red while the drive spins down. Once the LED stops flashing, the cartridge can be safely removed.

The rear of the unit features only a power socket and female port for connection to the interface board. A fan is mounted on the underside of the case. The case is ruggedly constructed from quite thick steel which could, at least, make the axe slip on the first blow and subject some damage upon its wielder. The case is only as high as the two drive mechanisms, which are SyQuest manufactured in the US. Behind the drives is some interface circuitry, an adequate power supply and the cooling fan.

The drives are of the stepper variety, which is pretty much as one would expect. Clearly this means that the performance attained by removable hard disk systems will not be as great as fixed voice coil devices mounted in most good '286 and '386-based PCs. However, it could validly be argued that many AT users do not really need the additional disk speed, and that a disk cache could match the performance with that of a voice coil disk. Of course, the idea of a removable hard disk running with a disk cache is fascinating. What happens if a whole bunch of writes are sitting in the cache when the user changes disks? Presto — two corrupt disks for the price of one!

This is not to say that caching is impossible with removable disks, just that a certain amount of care should be ex-

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A Tallgrass tape backup system sits in a floppy slot inside your MS-DOS compatible personal computer, or out of the way on the made-for-it ledge next to the monitor. Each unit fits your needs as neatly as it fits your PCs: You can choose from 20, 40 or 60 megabytes of storage. (Tallgrass goes beyond backup, serving as a readily-accessible archival storage system.) All work is safely backed up onto a 20, 40 or 60 Mb data cartridge. Plus, with the Tallgrass unique, free, automatic backup software installed, you can forget about backing up (many operators forget anyway!). Only Tallgrass provides continuous protection of your vital business records. And continuous peace of mind.

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John Bevins TG6

The Diskit-2 will sit neatly between the main system box and the monitor

ercised. Even mere application software is not above introducing complications. There was a PC user very experienced in the use of a particular database system, who purchased a single removable hard disk to complement his fixed disk, and corrupted both this year's and last year's database in one hit. The database system performed disk optimisation and did not fully close files until it really had to. The user was accessing a database on the removable volume and switched to the corresponding database for last year, stored on another volume. Unknown to him, the first database was not fully closed and the application software did not appreciate that the disk had been switched. When the file was eventually fully closed, it clobbered vital control blocks in one database with the control blocks from the other. Needless to say, the first database had not had its control blocks written, and so was also corrupted. And also needless to say, the user was far from impressed and soon developed the safe habit of exiting to DOS before switching disks. Of course, exactly the same situation could have occurred with a floppy.

The controller board plugs into any 8-bit PC slot and is full length. It features a couple of 40 pin VLSI chips, but none of the (what do you call them?) V-VLSI packages — the big square chunky ones with masses of pins and a small universe inside. The SSI and MSI component count is quite high: 45 chips to be exact. There is nothing wrong with this, it's just becoming more unusual to see. The board is well engineered with no late revisions or telltale 'yellow' wire. A single socket on the mounting bracket leads to the disk unit. A jumper selects between configuration as first or second disk drive. A BIOS ROM is provided to allow booting directly from the hard disk.

The Diskit-2 provides optional DES data encryption implemented in hardware. This is a handy feature and guards against some burly safe-cracker blowing his way into your stash and making off with the data. An eight character password is chosen when the disk is first formatted and must be supplied for all subsequent use. The DES standard was developed by IBM around a decade ago and is now widely used in commercial data encryption. The data is encrypted in 64byte chunks, with the key for each chunk being derived from the previous one. No record of the password is kept on the disk or in memory. It sounds good, and it is. Indeed, when it was first developed, DES was considered completely secure since, although theoretically breakable, it was considered that any foreseeable amount of computing power would require so many years to break the code that the information would be worthless when finally decrypted. Of course, since then developments have moved on and almost every major security agency runs supercomputers more than capable of breaking DES encryption on a daily basis. It remains good protection against the dedicated hacker with a couple of months to spare.

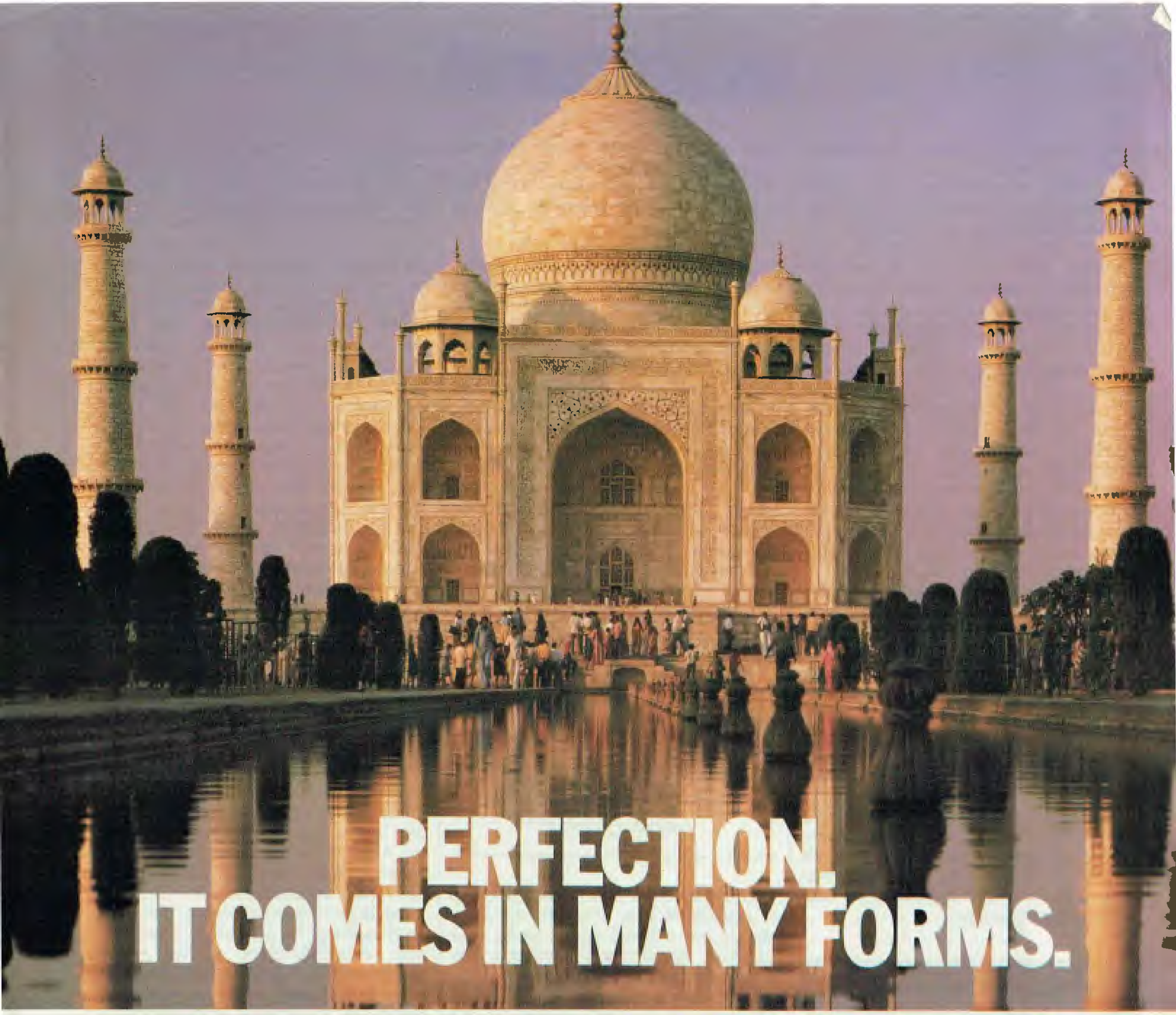
Bernouilli's Box . . .huge compared to the tidy offering from IDEAssociates

Installation is a breeze. The board is inserted, the drive unit placed below the monitor, and the two plugged together. Installation instructions come in the form of a single sheet fold out with lots of pictures and hardly more than a few words in each frame. It couldn't be easier and is not in the least daunting. The only thing missing in the whole installation was a power cord, but being a review machine, it had probably been thieved by some other reviewer from some other magazine to use in some other kettle.

An installation program is then run from a floppy disk provided to format the drives and install the operating system. The program asks you to insert your normal DOS disk and copies the relevant hidden and system files onto the cartridge, even allowing for OEM file naming variations. The installation software verifies the system configuration and connections to ensure all is well, and deals with other bootable drives and controllers, if any. Although it is possible to make a cartridge bootable, this was met with little success. The POST (power-on self-test) routines managed to find the optional disk BIOS ROM, but the cartridge was always found not ready. Possibly this was caused by some subtle problem with the Olivetti M24, or a good old user error. It proved no great problem, however, as the install program happily created a boot floppy which contained the necessary AUTOEXEC.BAT, CONFIG.SYS and associated drivers.

The boot sequence was excruciatingly slow, but this was probably caused by the drives coming up not ready. Even on a warm boot, the POST took at least 90 seconds to pass through the drive check. Undoubtedly this process would be significantly faster from a bootable cartridge.

The documentation is good. It's a ring bound loose leaf affair without the ring binder. It is clear, readable and goes into adequate (possibly slightly excessive) detail on every step of



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457 N

the process. But it lacks a set of technical specifications.

A utility supplied on the floppy provides an alternative to FDISK for volume partitioning and activation. An ICOPY utility provides an image copy function from one drive to another, probably the easiest means of performing a total backup and with the most satisfactory result. IBACKUP and IRESTORE utilities are provided to perform multi-volume backups from non-removable media to one or more cartridges. These would seem best avoided, if possible, as they incur the same inherent problems as the DOS BACKUP and RESTORE commands. It seems far preferable to use a normal DOS COPY command if at all possible, thereby having a fully functional backup rather than some static image which must first be restored to be of any use.

The general purpose utility program also provides functions for drive testing, hard formatting, DOS formatting and a handy bad sector function which will mark bad sectors as unusable. This is a great improvement over normal DOS, which is only able to handle bad sectors at format time. Any bad sectors found after the disk has been formatted cannot be marked as bad without first offloading all the data, reformatting and reloading. The utility even asks what to do if a bad sector, which is currently owned by a file, is found. All utilities may be run in either menu or command line mode for user or batch file operation.

Bernoulli Box

The Bernoulli Box is also a twin removable system, available in a variety of sizes down to dual 10Mbyte drives. The model provided for review supplied 20Mbytes of space on each cartridge.

Whereas the Diskit-2 is small, slim and discrete, the Bernoulli could easily be described as a brute. It comes tucked inside a huge packing case which could easily hold an AT compatible complete with user, family and dog.

Opening the pack is a voyage of discovery. Anyone expecting to find an elegant, petite disk drive reclining amid masses of packing foam is going to be sadly disappointed. It's a thumper, about the size of a small PC, perhaps a little smaller. It's size is almost intimidating, as though it's daring you to drop it. The aura is well deserved, it seems. This box can take rough treatment and a user could feel very comfortable in its use. The long interface cable is an admission that the unit was designed for ruggedness rather than aesthetics, and that many users will not want to place it directly next to their PC.

The Bernoulli Box takes quite a different approach to magnetic media. Whereas the Diskit-2 is essentially a hard disk platter removed to a cartridge, the Bernoulli is something unique. The media is flexible and uses air flow to maintain a degree of rigidity when operational. The air flow assists in pumping foreign bodies off the surface of the disk, and the media will actually flex around a particle rather than be destroyed or damaged by it.

In fact, Sourceware, the local distributor, encouraged a rough treatment it uses in its demonstrations. Staff at Sourceware suggested the front of the unit be lifted a couple of inches and dropped onto the bench while the disk is actually in use. Then the cartridge should be removed and dropped onto the floor. Apparently the Bernoulli Box thrives on this sort of thing.

> *'What happens if a whole bunch of writes are sitting in the cache when the user changes disks? Presto — two corrupt disks for the price of one!'*

Part of the reason for its high tolerance of physical violence is the media flies next to the head rather than vice versa. In other words, the head is strongly mounted and lets the media come to it, whereas most disks use a highly rigid media and try to fly the head as close as possible to the media. The so-called 'Bernoulli effect' created by the 'Bernoulli plate' is responsible for keeping the media rigid near the head.

The argument is that in normal disk drives, a drop will cause the read/write head to come into physical contact with the disk surface, whereas dropping the Bernoulli Box simply causes the disk to move further away from the head.

It's really all quite clever. The spinning flexible disk causes air to be pumped from the centre towards the outside. This causes a low pressure region between the disk surface and the stationary 'Bernoulli plate', thereby sucking the media up until it is in close proximity to the plate. However, stationary air next to the plate prevents the two from actually coming into contact. Additionally, the constant flow of air helps purge any contamination, and the flexible nature of the media means that minimal damage is done by any particles which should find their way in. Finally, the read/write head itself acts like a miniature Bernoulli plate to provide even greater accuracy where it counts. The final result is head positioning to within one micron. Not bad.

The cartridges are about the size of an A4 sheet of paper, and around 1.5 centimeters in width. They're large, but solid looking. They can be shaken and dropped without any sign of a rattle, just the occasional clatter. The casing is high impact plastic, and could probably be shattered onto a concrete floor if hurled from sufficient height. The disk surface is completely enclosed and features the usual automatic protector retraction upon insertion. The protector mechanism appears to be child proof, certainly reviewer proof, and it is virtually impossible to gain access to the disk surface. The best one can do is peek through a gap and see a portion of the media flopping about within the case. There is not even a hub, presumably this is also hidden behind the protector. A discrete write enable switch is located at one corner of the cartridge and cannot be accidentally activated.

The biggest disadvantage to the Bernoulli cartridges would seem to be their size, 280x209x18mm at the minor weight of 590g. It would only be possible to squeeze about a dozen of these into an average size briefcase. Although emotionally less appealing, cartridge size should not be a major consideration in this type of purchase. If the application involved shipping cartridges around the country, certainly a smaller cartridge would have its advantages, but one must also consider the likelihood of the cartridges being subjected to severe treatment in transit.

The cartridges slide into large slots situated one above the other on the Bernoulli Box. A lock flips around to secure the disk in place, similar to those found on many floppy disk drives. When one considers the size of the cartridges, suddenly the size of the unit does not seem so great. Dual LEDs for each drive indicate disk access and status, with press buttons provided to manually spin down the disks. The rear of the case features only power and interface sockets, plus a large filtered fan outlet. The unit is

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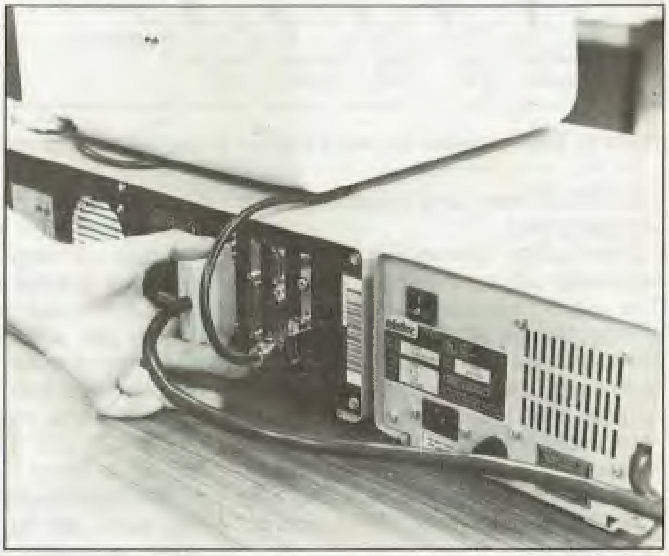

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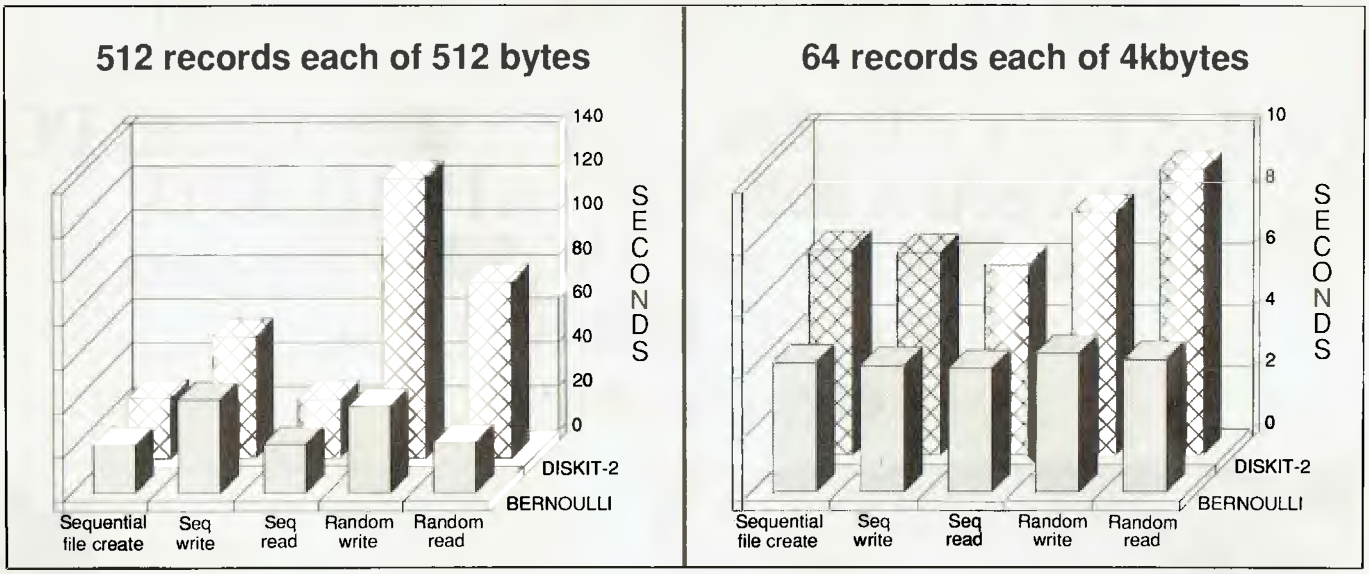

Refer to Table 1 below for exact timings shown in these graphs

160x317x387mm, and weighs in at a whopping 19kg.

Unfortunately, access to the interior is impossible without leaving major scars. The unit is sealed by small screws requiring the use of a star shaped Allen key. However, given that much of the technology used in the device is original and proprietary, one could reasonably speculate that there would be more than just 'off the shelf' components. Unusually, the actuator is a voice coil, and hence provides rapid access times.

The adaptor board is one quarter size and plugs into any 8-bit slot. It would have no trouble fitting into the short slot next to the power supply in true IBM PCs. The board features absolutely no VLSI components, so presumably these have been included in the external unit. A large connector on the mounting bracket leads to the box via a 1.5m flexible cable. Two adaptor boards are available: the PC2 which does not include the ability to boot directly from disk; and the PC2B. An upgrade kit is available which enhances a PC2 to a PC2B through the insertion of a couple of components and $249. Sourceware says that relatively few users opt for the PC2B, which is rather surprising. The interface card is well constructed, obviously a stable design and includes a bank of DIP switches for configuration.

The lack of a BIOS ROM on the board is a potential area of compatibility problems. Although fewer and fewer software products delve down to the BIOS level for disk I/O (that ended when Tallgrass introduced its product), possibly one or two still exist. The Norton Utilities used to call the BIOS for hard disk I/O until version 2, and now stay way above that level, restricting themselves to the INT 25/26 DOS functions. Possibly some software still exists, somewhere, which uses the BIOS calls, but it certainly wouldn't be anything to worry about.

Documentation consists of separate installation and user guides. The installation manual is brief and to the point with copious diagrams. Configuration of the DIP switches on the interface board is made by running the SETUP program, which recommends what the settings should be. This is not such a great idea. Usually, the installer will already have his PC half stripped down by the time he discovers the program must be run. Similarly, if he wants to refer back to the configuration options in the middle of a particularly delicate manoeuvre, there is an increased chance of power being applied before the interface card is properly seated. It seems like a good idea, but has been tried before. Some PC manufacturer supplied a disk which provided a step-by-step guide to installing hardware options, and the thought of someone trying to run the disk and install the hardware at the same time is just too terrible to contemplate.

It is fortunate that, as the DIP switch options are also buried at the rear of the user manual, they end up being nothing of any interest, and the factory settings are usually appropriate.

Performance tests

TEST	DISKIT-2	BERNOULLI
Sequential BIOS seeks	54.80ms	NP
Random BIOS seeks	136.4 ms	NP
Random sector reads	187.75ms	70.80ms

(All timings in seconds)

	A	B	A	B
Sequential file create	27.3	6.7	22.0	4.2
Sequential write	55.0	6.6	42.4	4.1
Sequential read	26.6	6.2	21.8	4.0
Random write	126.4	7.9	39.7	4.5
Random read	79.3	9.3	23.1	4.3

Notes: A is 512 records each of 512 bytes
B is 64 records each of 4k bytes
NP = not possible to run

Table 1 Benchmark performance results

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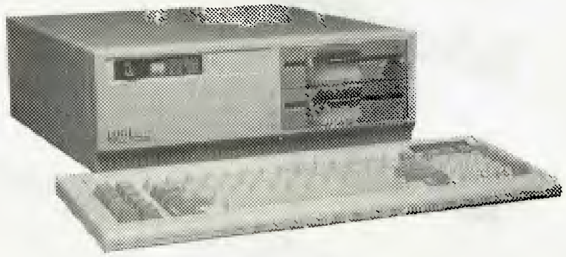

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Table 2 Technical specifications

PARAMETER	DISKIT-2	BERNOULLI
Drives	2	2
Mbytes/drive	10.6	21.43
Track density (tracks per inch)	741	639
Platters	1	1
Actuator type	Stepper	Voice Coil
Media type	Rigid	Flexible
Average access time (ms)	-	38
Sector interleave	1:1	Variable
Recording method	MFM	RLLC
Mean time to failure	10,000 Hrs	10^{12} I/O
Vibration	0.5G peak-peak	0.85G at 5-17Hz
Shock (operating)	10G for 1 ms	3G for 20 ms
Power consumption (W)	40	50
Dimensions (mm)	56x330x386	160x317x387
Weight (kg)	8	19
Cartridge dimensions (mm)	12x107x107	18x209x280
Cartridge weight (g)	140	590
Bootable	Yes	Option
Image copy utility	Yes	Yes
Backup/restore utility	Yes	Yes
Cartridge software lock	No	Yes
Encryption	Yes	No
Additional controllers available	Yes	Yes

A SETUP program creates AUTOEXEC.BAT, CONFIG.SYS and associated driver files on the boot diskette, as well as copying the DOS hidden and system files onto the Bernoulli disk if it is to be bootable. The SETUP program is very cautious, always explaining what it is about to do and asking whether it should continue.

The user manual includes general information on the care and feeding of disk cartridges, effective use of the system for backups, use in network environments. Again, the manual is well written, well constructed and is easily digested. The quality of the manual is not as critical with this sort of product compared to an application system, as the user will generally consult the manual only once when first installing. Rarely would a user refer to the manual on a daily or even weekly basis. Since the utilities might be an exception to that, a quick reference card is provided. Finally, and always good to see, the rear of the manual contains technical specifications.

A suite of utilities is included on the distribution disk providing BACKUP, RESTORE and image COPY facilities. Additional utilities provide FORMAT, PARTITION and installation functions. A particularly useful (if not essential) utility allows the disks to be locked such that the user may not remove them. This could be a life saver, and a system implementer could lock the disks before entry to application software, only unlocking them upon exit. An option in the CONFIG.SYS driver allows all disks to be locked by default.

The installation program is particularly clever, as it formats disks with the optimum interleave factor for the PC used. Interleave is the difference between logical and physical sector numbering. For example, logical sector one may not be next to logical sector two, as a slow PC may not be ready to read the next sector by the time it is rotating past the head. By moving the next logical sector further around the disk, the PC has more time to finish digesting the previous sector. Clearly having too high an interleave factor would mean that the PC is always ready before the next sector presents itself, and would have to wait until it moved under the head. Too low an interleave factor and the PC would always be just missing the next desired sector, and would have to wait almost an entire rotation. Interleave only becomes significant where consecutive sectors are being read, which is often the case in cluster based operating systems such as MS-DOS.

Most hard disks are shipped with a predetermined interleave which attempts to provide a good middle ground. Most can be reformatted to a different interleave factor, but the user must chose what he thinks is appropriate — often by trial and error. The Bernoulli's ability to automatically optimise this for the user is a real bonus, and provides a high level of performance across the entire spectrum of machines. Of course, disks formatted with one interleave are readable on machines which really would prefer a different interleave, just do not provide optimal performance.

All in all, the Bernoulli Box gives off airs of quality. It is sturdily constructed, a little noisy, but best of all, could really make its user sleep better.

Pricing

At first glance, these boxes appear quite expensive. However, when one calculates the cost per megabyte, particularly taking into account the unlimited offline storage available, the prices start to seem very reasonable. Add to this the time saved in backups to floppies, or the invaluable benefit of backups which would not otherwise be done, not to mention the security aspect, and the deal looks like a bargain.

The Diskit-2 D1010 sells for $6895 including all the cables, interface board, two cartridges, cleaning kit and manuals. The D1010P with data encryption option is $8300. Alternatively, you can purchase just the drive for internal mounting in an XT or AT at around $3000. Additional controller cards are available at $900 each, or $1238 with encryption, thereby allowing the flexibility of plugging the one disk unit into multiple PCs for backup purposes. Cartridges are $245 for 10 Mbytes, and all prices include sales tax.

The Bernoulli Box 20+20, as reviewed, costs $7500 including all the bits and pieces, three cartridges plus cleaning kit. Alternatively, a 10+10 model featuring dual 10Mbyte drives is available for $5950. Top of the line is the PLUS, which provides an 80Mbyte winchester and dual 20Mbyte removable disks for just $11,250. Additional interface cards may be purchased for $487 a piece, with the upgrade to allow booting directly from the disk another $249. Cartridges cost $454 for a pack of three 10Mbyte disks, or $638 for three 20Mbyte disks.

Performance

Table one shows the performance results for each of the products, connected to the same Olivetti M24, with the same configuration and running with fresh disks. These tests should be pretty much independent of processor speed, as they are 100 per cent disk bound.

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The first test calls the BIOS routine 13h to test both the sequential and random seek speed of the disk. The sequential measurement is obtained by flipping back and forth between two cylinders as rapidly as possible one thousand times. This yields an empirical measurement of the track-to-track seek time. The random test seeks between one thousand random cylinders, and provides the average seek time. Unfortunately, the Bernoulli Box was unable to complete these tests due to the lack of BIOS routines.

The random sector read test calls DOS interrupt 25h to read one thousand random sectors. This measurement includes both the seek time and rotational latency, and so would be affected by the interleave factor. The Diskit-2 would probably show better performance on a fast 286 or 386-based system due to its unusual interleave factor of one. By comparison, IBM XTs have an interleave of six, and ATs have an interleave of three. According to the installation program, the Bernoulli Box should be showing optimum results no matter what speed processor it was connected to.

> *'It would not be at all surprising to see many users opting for removable disks over streaming tape backup units . . .'*

The results of these tests do not entirely agree with the manufacturers claims. That does not necessarily imply that their claims are incorrect, or that these tests are inaccurate, merely that there are many different ways of measuring anything. However, it is quite valid to compare the figures between the two products, as they were both exposed to exactly the same procedures.

The file access tests were run using MS-DOS 3.1, and measure the time to perform common application style I/O operations. The sequential reads and writes would be a good profile of spreadsheet and word processor I/O, where lengthy reads and writes take place in a sequential manner. Additionally, the sequential read test is a good model of loading a program, whether it be an application product, user program or DOS utility.

The random file I/O tests are more appropriate to database system performance, where direct access files are employed and there are few consecutive I/Os.

All of the file I/O tests were run both for a large number of small records and a small number of large records. It is very important to run these types of tests with a consistent machine environment, as they are heavily influenced by the CONFIG.SYS settings and disk fragmentation through previous use.

The clear result is that the Bernoulli outperforms the Diskit-2, by a comfortable margin. This is not surprising, given the fact that the Bernoulli uses a voice coil actuator and Diskit-2 employs a stepper motor.

Conclusion

The technology and principles embodied in these products certainly makes sound sense, and seems to address all or most of the disadvantages of hard disks and floppies. It would not be at all surprising to see many users opting for removable disks over streaming tape backup units, but probably configuring the system from scratch, rather than tacking a removable unit onto the side of a PC with an existing hard disk.

……

AD ■ In some ways, the removable magnetic approach could be seen as a stop-gap mixing of two technologies, a mere detour towards the 3000 Gigabyte read/write removable optical disk with zero access time. However, until that magic device appears, the approach addresses and solves several immediate problems.

For most users, price is going to be the issue. A cost justification taking offline storage, productivity, integrity and security into account should prove for itself the cost effectiveness of these devices. But it is still a lot of money to shell out.

On price alone, the Bernoulli Box wins, both for initial cost and the ongoing purchase of cartridges. On performance, the Bernoulli Box wins again, as clearly demonstrated by the figures.

For security, the Diskit-2 with option DES encryption has the edge. The Diskit-2 also wins if size is a consideration, both the size of the unit and the cartridges. Additionally, the Diskit-2 provides a quieter operation.

Both products provide good documentation, packaging, and a level of quality we should come to expect.

END

SOURCEWARE

Bernoulli Box - Removing the limits to growth

Experienced users are finding information storage management, security and reliability problems are occupying increasing amounts of time.

They ask themselves:

'Can I find an efficient solution which solves my immediate requirements, while giving me a safety net against future developments?'

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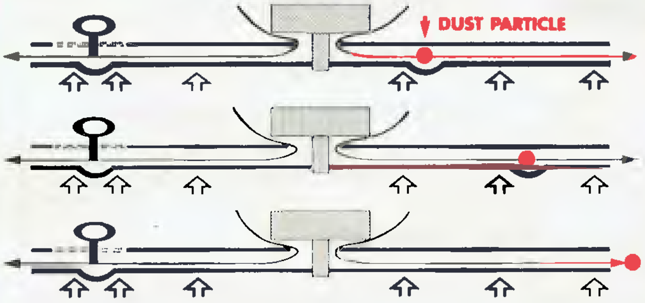
Have you been frowning a lot like this lately? Unsure about how you can safeguard sensitive data? Then read on for the Bernoulli Box solution.

How Bernoulli Technology Handles Contamination



Bernoulli technology causes the flexible media to wrap around any object between the flexible disk and the Bernoulli Plate. The air pumping action of the Bernoulli Effect pushes any contamination away from the centre and purges to the outside.

Lightning fast back-up and removable cartridge disk storage provide time savings, security and organisational flexibility.

Heavy computer users in many business areas such as finance, administration, banking, insurance, manufacturing, or CAD (computer-aided design) will find many applications for fast, reliable on-line storage with the convenience of a floppy disk.

Sourceware is offering the Bernoulli Box in three configurations - 10 +10Mb (dual 10Mb removable cartridge disk drives), 20 + 20Mb (dual 20Mb removable cartridge disk drives), and the Bernoulli Box Plus. The Bernoulli Box Plus caters for large scale networking and power users, and features dual 20Mb removable cartridge disk drives and a shock-mounted 80Mb fixed hard disk to provide 120Mb of on-line capacity. It comes with special software that may be used to allow you a full 80Mb of contiguous storage, overcoming the 32Mb limit imposed by DOS.

Low cost removable cartridge disks set the Bernoulli Box apart from its competitors.

A cartridge-based file management system gives you the best of both storage worlds. It merges the high storage capacity and speed of hard disks with the flexibility and ease-of-back-up of floppy disks.

The Bernoulli Box offers:

Speed

You can access on-line unlimited amounts of data, at speeds equal to the fastest hard disk drives (35 milliseconds), with no limit to the number of cartridges you can add.

Data security

Rugged design. Keeps data safe from the hazards of ordinary use and even extraordinary mishaps.

Removable cartridge disks. Lock up sensitive data in your desk or office safe for complete security.

The Bernoulli Box is really a life saver. You can lock away your worries forever.

Bernoulli anti-shock, anti-contamination technology. The disk has built-in resistance to shock, vibration and contamination, protecting it from head crashes, which can destroy data.

Easy to use back-up

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Hard disk back-up. Transfer rate is several times faster than standard DOS back-up utilities.

Bernoulli Box vs.	Fixed Hard Disk (With Tape)
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Transportability	
Move from Bernoulli Box to Box and send via post	Disk can't be removed from system.
Protection	
Password. And lock in safe for total security.	Password only.
Backup	
Cartridge to-cartridge backup in 4-6 minutes	Tape backup not directly usable.
Return on Investment	
Expand indefinitely by adding low-cost cartridges.	As capacity is reached, a major investment is required.

The only choice in PC mass data storage - Bernoulli Box.

Transportability

Cartridges are completely interchangeable. Send them across the hall or around the world.

Manageability

Use your removable disks to build a cartridge library - organised by task, department, function, date, user or any category you choose.

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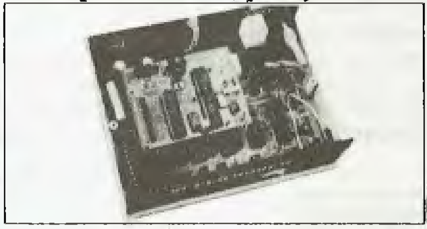

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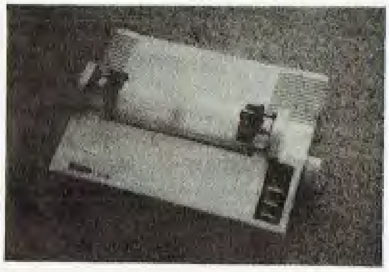

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Hard disk storage

What type of hard disk should you buy? Ian Davies looks at three popular types — voice coil, stepper and internal hard disks 'on a card' — and explains the merits of each.

Storage technology has been progressing in leaps and bounds ever since the days of mercury filled echo delay tubes.

The 60k floppy has given way to the 1.2Mbyte floppy. The crude 5Mbyte hard disk of yesteryear has been superseded by swish 40 and 80Mbyte voice coil jobs found tucked away in ATs and '386 based machines. A slight detour was made through magnetic bubble memory, thought to be the way of the future but eventually found to encompass all the worst aspects of everything (except in some special applications).

Meanwhile, the 500Mbyte laser disk is on a rampage, with the gradual introduction of WORMs and true read/write optical media. Added to this, we have the burgeoning communications industry with ever increasing bit-rates and the promise of 2Mbit/sec links into the home, raising the spectre of a community database and placing a shadowy question mark over the very need for ultra-high capacity local storage.

Yet despite all the high-tech developments taking place, one of the cheapest forms of mass read/write storage remains the humble magnetic media. Moreover, magnetic storage is available in a variety of appropriate sizes. While a 300Mbyte WORM may be more cost effective, few users have a real need for such a high volume, and would gladly pay one tenth the price for one thirtieth the space.

Regardless of its 'mature' status, magnetic media technology is certainly not standing still. At the high end, developments are forging ahead in larger capacities and better access speeds. And as is usually the case with these things, the low end prospers from better availability, more configurations and much lower prices. It has now reached the point where low end hard disks are a consumer level item — one can wander in off the street and say "'Allo, I'd like a 'ard disk please', take it home and plug it in.

Securing a hard disk for under $1,000 is as easy as looking in *APC*, and many deals are around for less than $800.

However, more and more users are turning toward to the top end of the market. Requirements vary. Some users need to retain their dual floppies and prefer a hard disk on a card. Others require the security and backup advantages of removable cartridges (see a comparative review of two popular unitson page 7). Others seek speed.

Of course, performance is a common need — but often perceived rather than required. The corporate PC has taken off to such an extent, if only as a status symbol, that the moment some paper pushers develop a Lotus spreadsheet larger than a screen they get all fired up to rush out and buy a '386 system with 80 Mbyte voice coil. Often higher performance can be achieved without additional hardware purchases, and this will be dealt with later.

Currently, there exist three main choices in non-removable hard disk technology — the disk on a card, the front mounted stepper, and the front mounted voice coil. Of course, disks are also available externally, but these are becoming relatively rare. We will examine all three types with a view to how they work, how much they cost, and what they deliver for the price.

Disk basics

All disks operate in essentially the same fashion. The disk surface is coated with a magnetic media, similar to that used on audio cassettes. The disk spins rapidly on a spindle, at a rate of about 3600rpm. A read/write head, again similar to that used in a cassette recorder, is mounted on a retractable arm.

An audio cassette uses a fixed head and tape moving at a constant speed. The mechanism is inherently sequential, as the head has no choice but to wait for the desired portion of tape to arrive underneath it. To move from any point on the tape to any other point necessitates passing through all other points in between. However, the magnetic technique of reading and writing, and the rewritability of the medium, is essentially the same

In other ways, a disk is like an audio record, in that the head may be lifted and moved rapidly to some other point. This is known as random access.

Whereas an audio record uses a spiral track, a computer disk employs a series of concentric circles. The head is shifted over the desired track, and then simply waits for the desired piece of information to pass underneath it. Each track is broken into discrete quantities known as sectors, and each sector is numbered. Operating system dependent mechanisms group the sectors into clusters, and provide directories of which clusters a file occupies.

The speed with which a disk can access a required sector is dependent upon two factors. First, the disk must shift its head to the appropriate track. This is known as the seek time. The disk must then wait until the appropriate sector passes underneath it. This is known as the rotational latency. Clearly both are subject to enormous variability, as the time to seek to any given track will depend on where the head happened to be at the time. Similarly, the next sector to pass by the head is largely unpredictable. On a lucky access, the required sector will be the very next one to go by, but it may also have just been missed and the disk will have to wait almost an entire rotation. Some multi-user operating systems are sufficiently smart to schedule I/O seeks. For example, although a user may have only just requested his I/O and there are ten other users in front of him, it can be more efficient to carry out his I/O while the disk head is in the neighbourhood. In this way, complex operating systems can prevent the head scuttling excessively from one side of the disk to the other.

It is important to realise that, in computer terms, disk I/Os take a small eternity. Simple micros, such as MS-DOS systems, are incredibly crude in the way they do nothing other than wait while an I/O is in progress. Any decent multi-user or multi-tasking system could never get away with that sort of lackadaisicalilty, and must continue utilising the CPU on other problems while the I/O is in progress. In fairness, any micro with an interrupt structure can be programmed to put disk access time to good use, but in a single-user/single-task system, the question arises "what else is there to do?". Several products are available for PCs which put this time to good use. However, in a standard MS-DOS system running a disk intensive application, the speed with which the hard disk can respond will act as a governor on overall system performance.

Rotational latency can be shortened simply by making the disk spin more quickly. This can be achieved relatively easily, since the rotation is of a constant speed and the drive may take many seconds in spinning up to a good, smooth speed. The end result is that Newtonian mechanics works for you and not against you, a delightful situation. Disks already spin at quite a respectable rate, so that main area of improvement lies in the more complex area of head movement.

Unlike the disk, which moves in a constant (angular) direction, the disk head continually changes its linear direction of movement, pausing motionless over desired tracks. The challenge is to build a light weight head which can very rapidly be moved from track to track. The head is subject to both acceleration and speed. This means that the head must accelerate quickly to a high speed, and decelerate quickly to an accurate stop. The degree to which it can accelerate, and the final velocity attained governs the final time to seek between any two tracks.

This seems obvious, but is not as simple as first meets the eye. Different seeks will be of different lengths, and a head actuator which can accelerate very rapidly, but only to a low speed, will provide good performance over short seek distances and lesser performance over large seek distances. Conversely, an actuator which provides equal or lower acceleration, but attains higher speeds will be able to seek more rapidly between distant tracks.

Clearly the critical factor is the distance of a seek. In an ideal situation, no seek will be required and the next sector to be read will be on the same track as the first. A nearly optimal scenario is when the next sector is located on an adjacent track. The worst case is two sectors on opposite ends of the disk. On average, not allowing for smart operating systems, half the disk will have to be traversed from one access to the next.

In recognition of this, several manufacturers offer multiple platters and/or multiple heads.

A multiple platter system uses several disks mounted on the one spindle. This means that a given storage capacity can be achieved in a lower disk diameter. In turn, this means shorter average seek distances and therefore better access speed. The arrangement of tracks located an equal distance from the centre of the spindle is called a cylinder, and all sectors in the same cylinder may be accessed without moving the head. Separate read/write heads are used for each platter and are ganged on the one actuator, meaning that they all move at the same time. Reasonably smart operating systems, such as MS-DOS, recognise this fact and cluster sectors together using the same sector number on each platter. Thus an entire cluster may be read without head movement.

> *'upgrading either the CPU or disk on its own would be like buying better speakers for an old stereo'*

In the simplest of cases, a drive employing a single physical disk, or platter, provides multiple surfaces merely by utilising both sides of the disk. Most hard disks work this way, although some don't. Thus a floppy disk may be considered a single platter, dual surface system. In other words, providing two tracks per cylinder. Most 20Mbyte drives employ two platters, and hence have four surfaces (tracks/cylinder), along with four read/write heads. In large mainframe disk systems, it is not uncommon to find as many as 30 tracks per cylinder.

The other way to minimise head movement is through the use of more than one read/write head per surface. In this scheme, a head is placed at the end and half way points on the actuator arm. The outer head is responsible for accessing the outer annulus of the disk, and so with the inner. Hence the total actuator travel required to access any point on the disk is halved. Again, some mainframe devices go overboard on the idea and provide dozens of heads per surface.

Interleave

When a computer needs to read sequentially from a series of sectors, the so called 'interleave factor' comes into effect.

In the simplest case, a given sector might be read and the next sector required by the computer is the next sector number on the same track. Clearly no head movement is involved and the drive need only wait until the following sector is passing by. Even with multiple surface media, the situation is essentially the same since all sectors of the same number pass by the heads at the same time regardless of which surface they are live on.

The problem is that disks spin rather rapidly compared to computer speeds. At 3600rpm and 17 sectors per track, the time between the end of one sector and the start of the next is negligible. The chances are that by the time the computer has realised it wants the next sector, that sector will have passed it by and the controller will be forced to wait a rotation.

To combat this problem, a distinction is made between physical and logical sector numbering. Physical sector numbers are purely conceptual, and are totally contiguous. That is, sector one is followed by two is followed by three, and so on. However, the logical sector numbering, which is actually used by the controller to locate the desired sector, may place sector number two six sectors on from sector number one, and so on. The hope is that the six sectors breathing space will be sufficient time for the processor to realise it wants the next sector, and so the I/O request and the passing of the sector by the head will happily correspond.

It seems amazing these days that disk I/O is not completely handled by DMA (Direct Memory Access (hardware to hardware (who ever heard of nested brackets in English ?))), yet DMA to disk is something only just emerging on the higher performance processors. In most low end micros, the transfer of data from the controller to memory is managed by the CPU.

The interleave factor can greatly affect overall disk performance, and should ideally be matched to your processor speed. For example, the

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original IBM XT used an interleave of six. The IBM PC/AT uses an interleave of three. Some very fast processors use an interleave of one. It should be noted, however, that pruning the interleave factor too closely can be counter productive. If the processor ever takes slightly longer than usual before requesting the next I/O, the target sector will have passed it by and it will be forced to wait an entire rotation. Therefore a safe bet may be to choose an interleave factor one higher than that theoretically required.

Actuator types

The two main actuator types in use today are stepper and voice coil.

Stepper motor type disks are by far the most common, being based on well established technology. The motor is an off-the-shelf component used in all sorts of technologies, even some outdated radio control servos.

A stepper motor is really a glorified ratchet, and moves from defined position to defined position activated by pulses. Its characteristics are high acceleration but low speed, and good accuracy for little effort. This means that it can move quite rapidly between adjacent tracks, but suffers over long seeks since a seek of 20 tracks is really just 20 steps of one track (less 20 head settle times).

A voice coil actuator, on the other hand, is a linear induction motor. As such, it knows no defined stopping points and may reach very high velocities on lengthy seeks. Although the acceleration (and certainly deceleration) may not be as good as a stepper, the speed attained on long seeks will more than compensate. A voice coil actuator requires more complex electronics since the control is built into the logic rather than mechanical bits and pieces. Voice coil drives tend to be more expensive, even though containing fewer moving parts.

Most AT and '386 class systems provide voice coil drives, although some achieve commendable performance through stepper motor drives with smart controller cards.

User requirements

Despite many user perceptions, user requirements are often quite modest. Most word processing or spreadsheet application is not disk intensive, requiring only an initial load of the software followed by occasional data loads and saves. Small database applications are certainly not disk intensive, and any disk bottlenecks can be adequately addressed by disk tuning. Large database applications, large scale desktop publishing and software development are generally disk intensive.

Installing a fast disk into a slow computer may achieve very little, even assuming optimal configuration. Take the case of software development, where compilation time must be reduced as far as possible. Compilation is often both disk and CPU intensive, and so upgrading either the CPU or disk on its own would be like buying better speakers for an old stereo, or playing a new stereo through an old speaker — it helps, but it doesn't do justice.

Memory resident spreadsheet recalculations, for example, are entirely independent of disk speed and any heavy spreadsheet application would generally do far better on a faster CPU than a faster disk.

Some users have relatively unusual requirements, such as the need for an external drive. This can be desirable when the PC is often physically moved for demonstrations or data acquisition.

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Hard disk reliability is often affected by the number of moves and the care with which the moves are performed. Users in this situation would often be pleased to be able to leave their hard disk behind without a major screwdriver job. Similarly, programmers developing low level operating system software may appreciate the peace of mind in disconnecting their main hard disk before testing their software. External disks are becoming quite rare, and often consist of an internal drive mounted in a separate box with a power supply and a significant amount of additional money.

Machines which are shared by many users sometimes only contain application products on their hard disk, each user carrying their spreadsheets or documents on private floppies. This type of machine is often required to perform floppy to floppy disk copies — an operation which is far less painful on a dual floppy system. For these machines, hard disks on an expansion card are made to order. Hard cards cost a little more than a similar front panel mounted device, due to the extra effort involved in squeezing everything down to 1.5cm in width. Hard cards are also useful when an additional disk must be added to a system which is already running its full complement of front panel mounted devices.

Performance

Table 1 shows typical performance of the three main types of drive. Naturally, specific models may perform either above or below these profiles. The trend, however, is representative.

The seek tests call the BIOS routine 13h to move the head from one cylinder to another. They do not attempt to read anything from the disk, or locate a particular sector, they just measure the head movement time. The sequential test is the average of 1000 runs and indicates what is often referred to as the 'track to track' speed of the disk. The random test is again an average of 1000 and is more representative of the 'long haul' seeks which take place in a system.

The seek tests are delightfully simple. They are not affected by rotational delays, interleave, DOS buffers, processor speed, disk fragmentation, bad spots, or any of the other considerations which plague more complex disk tests. They purely and simply measure the time to move the read/write head.

The sector read test uses DOS interrupt 25h, and is the average of 1000 random repetitions. The time measured includes the head seek time plus the rotational delay. This indicates how well the interleave is matched to the processor, as ideally the sector read time would be very close to the random seek time. Again, fragmentation and DOS buffers do not affect the results, but processor speed and bad spots may.

The file access tests encompass all considerations, and are run for a file of 512 records by 512bytes, and of 64 records by 4kbytes. The sequential read is typical of loading an application program, spreadsheet or document. The sequential write is typical of saving spreadsheets and documents, although some systems may more closely resemble the sequential create. The random reads and writes are more typical of advanced applications such as database systems and spell checking.

All of the file access tests are affected by the DOS BUFFERS setting in the CONFIG.SYS file. Many users are not aware of this parameter, and rush out to purchase a faster disk when thirty seconds with an editor may have provided them a significant performance boost. The BUFFERS parameter controls how many sectors DOS can keep in memory at one time. When a disk sector is required, DOS searches through its buffers and returns it from main memory if possible. Avoiding a disk I/O in this fashion can greatly improve system throughput.

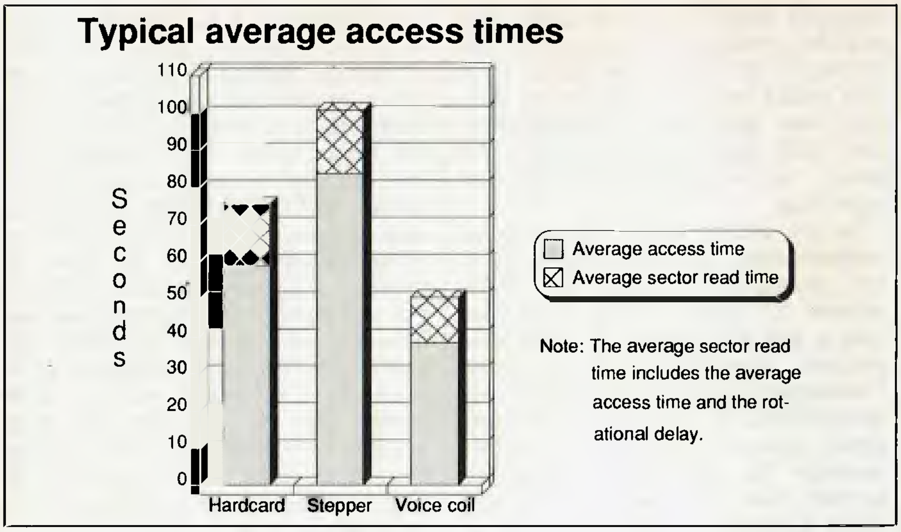
Some sectors are more heavily used than others. Two copies of the FAT (File Allocation Table), for example, are maintained in the first few sectors of a disk. The FAT controls the linking of clusters (groups of sectors) together into complete files, and is perhaps the most critical area on the disk and also the most heavily used. Directory sectors are also frequently accessed. The default BUFFERS setting depends on your system, but is usually something quite inadequate, such as three. By creating a file named CONFIG.SYS in the root directory of your boot disk and including a line such as BUFFERS=50, many disk intensive operations can be massively improved. A maximum of 99 buffers may be allocated, with each consuming 528bytes of RAM. The optimal BUFFERS setting depends on your application, and is best arrived at by experimentation.

The file access tests are also affected by disk fragmentation. In an ideal case, a 256k file will find 256k of contiguous free space for its use. However, as a disk is used, file creation, deletion and extension causes the free space to be fragmented into smaller portions. Thus a 256k file created on a very old disk may have to reside in dozens of smaller chunks, scattered over the entire width of the disk.

DOS 2.x and 3.x use different cluster allocation algorithms, and so fragment the disk in different ways. The DOS 2.x method was to allocate extents of free space as they are found searching from cluster zero, using the FAT. The DOS 3.x mechanism is to begin the search starting from the cluster just

	Hard Card	**Stepper**	**Voice Coil**
Capacity (Mb)	20	20	20
Cylinders	613	610	614
Read/Write Heads	4	4	4
Sectors/Track	17	17	17
Sector Size (bytes)	512	512	512
Total Sectors	41735	41531	41751
PERFORMANCE			
Sequential Seeks(ms)	14.4	20.3	7.7
RandoSeeks(ms)	59.1	83.8	38.4
Random Sector Reads (ms)	75.5	100.9	50.6
File Access 512 records each of 512 bytes			
Sequential Create (s)	26.7	14.4	10.4
Sequential Write (s)	33.4	12.3	10.3
Sequential Read (s)	10.6	12.0	8.9
Random Write (s)	53.2	34.3	24.4
Random Read (s)	33.5	28.5	17.6
File Access 64 records each of 4k bytes			
Sequential Create (s)	9.6	5.8	2.9
Sequential Write (s)	5.4	4.6	2.8
Sequential Read (s)	5.3	4.5	2.6
Random Write (s)	8.8	6.6	3.5
Random Read (s)	6.4	6.6	3.4

Table 1 Typical specifications and performance



Note: The average sector read time includes the average access time and the rotational delay.

used. The new mechanism tends to ensure that all portions of the disk are used from time to time, whereas the 2.x method concentrated most file activity at the outer edge of the disk. The new allocation algorithm tends to exacerbate the fragmentation problem.

Fragmentation is a serious problem, yet it can be both measured and controlled. The humble CHKDSK command includes a little known option to report on fragmentation for any given file. Simply place the name of any file or wildcard specification after the command and it will report the number of non-contiguous (fragmented) extents for each file matching the specification in the current directory.

Fragmentation can be cleaned up simply by copying all files onto floppies, erasing everything on the hard disk including all subdirectories, and then reinstalling the files from floppy. It is probably a good idea to reformat the hard disk instead of just erasing, to start with a completely clean slate. The order in which the files are copied back onto the hard disk is quite significant. You should start with static (never changed) files which are rarely used, system utilities and the like. Next to be copied should be the often used static files, 123, dBase, your word processor, compilers or whatever. Finally, you should add the dynamic files, spreadsheets, source code, databases and documents. This will ensure that the lower extremity of the disk is completely full and rarely accessed. The middle of the disk (or upper lower portion) will be completely full and often accessed, with the upper section being dedicated to dynamic files and allowed to fragment as much as it likes. This strategy contains the fragmentation and reduces head movement.

Of course, there is little point in defragmenting files which are constantly changed, as they will just refragment next time they are altered. Databases are a special case, as records are both updated in place and added to the end of the file. This means that the front portion of a database may be fully contiguous, but will fragment at the end as records are added.

Some users with very large hard disks use the FDISK partitioning utility to break their volume into two separate portions. In this way, they may maintain static files on one volume and dynamic files on the other, thereby containing their fragmentation.

Other users employ disk cache software. These products essentially extend the buffering offered by DOS. Whereas DOS uses a 'write through' strategy, that is, changed sectors are written back to the buffer and also immediately to disk, disk caches may leave changed sectors in memory for extended periods of time, flushing to disk only when really required. This certainly improves performance, in certain cases raising the throughput of a stepper motor drive to that of a voice coil, but does involve higher risk. If your machine hangs or crashes, some very important sectors (most likely the FAT) may not have been flushed and the result will be many corrupt files. The same can happen without a disk cache, but is less likely.

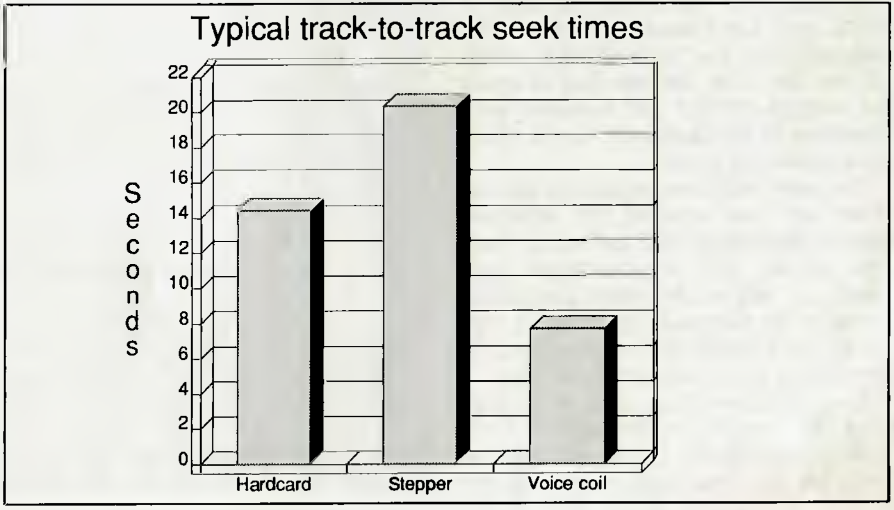
Results

The surprising result shown in table one is that the hard card generally outperforms the front mounted stepper motor drive. The voice coil drive beats both by a comfortable margin, as expected. The usual speed measurement for hard disks is the 'average access time'. On the original IBM XT, this was in the order of 70-80ms. On the IBM AT, the average access time is around 40ms.

Looking to table one, we can see that the voice coil drive is providing very good performance, with an average access time of 38.4ms. The stepper motor drive achieves a quite ordinary speed of 83.3ms. The hard card (which also uses a stepper actuator), provides the slightly better speed of 59.1ms.

The stepper and hard card obviously have an equally appropriate interleave factor, since the difference between the sector read and seek times are 17.1 and 16.4ms, respectively. The voice coil drive has a slightly better interleave configuration, with a differential of only 12.2ms.

The file access tests are the most significant measurement for end-user throughput, but also contain the greatest number of variables. All three disks were configured as closely as possible for these tests, but user results may vary from these findings depending on environmental considerations.



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The choice of a hard card is usually motivated by space, not performance. Yet the figures indicate that there need be no performance penalty in selecting a hard card. Some hard cards provide even better performance, with an associated higher cost. Others provide extremely low levels of performance — an average access time of 100ms or more. Choosing one of the lower grade drives certainly would be making a sacrifice, and probably not at a very great saving.

Front panel mounted stepper motor based drives are the most common devices used in PC and XT clones. Almost all offer an average access time of around 70ms, again some are better and some are worse, but the variation is not as large as that found in hard cards.

Voice coil drives usually offer around 40ms average access time. A voice coil user is most definitely going for performance, and so should take the trouble to ensure his system configuration is optimal, especially the interleave factor. To do otherwise is wasting an investment in performance. Drives faster than 40ms are available, some as low as 28ms, or even 22ms. The user however, pays dearly for every extra millisecond saved, and should carefully consider the benefits offered.

Most AT and 386 systems are sold with voice coil drives, as some people consider that to do otherwise would severely compromise the performance potential of the system. That is not true in all applications, however. For example, a highly CPU intensive modeling or analysis application dealing with very small data files which are rarely accessed could perform just fine on an expensive '386 system with a cheap stepper hard disk.

As always, it all comes down to what you really need, and that depends on what you plan to do with it.

Prices

Prices, as always, vary.

An average quality half or full height front panel mounted drive using a stepper motor actuator will probably cost between $800 and $1000 for 10 or 20 Mbytes. A similar quality and capacity hard card costs a little more, between $1100 and $1500.

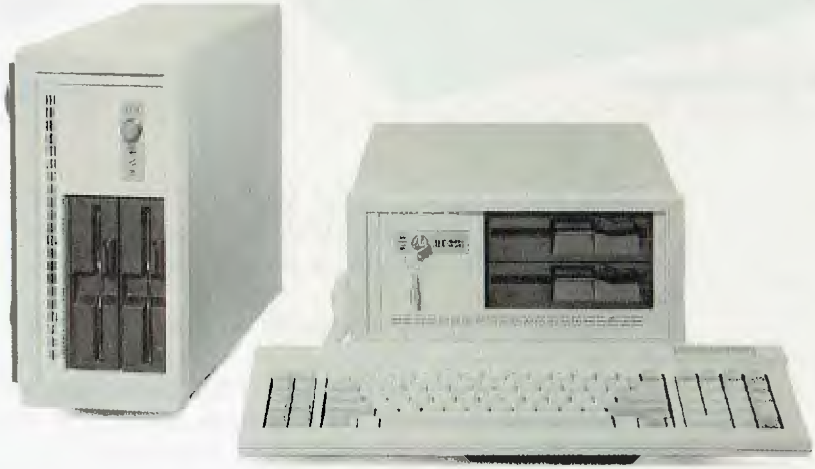
Voice coil drives are more expensive, between $1500 and $3000 depending on speed and capacity, up to over $10,000 for extremely fast units.

Conclusion

Of course, in all categories, some deals are better than others and often named brands will cost a little extra. The wisdom in selecting a named brand is the same as in anything else — there are certain advantages (sometimes perceived rather than real), and often extremely satisfactory purchases can be made without the benefit of a brand name. Stories abound of disk quality. It is always possible to find someone who warns against a particular brand, relating second or first-hand horror stories of reliability and disk errors. But for each one, there are other happy users who will praise the virtues of the brand. To a large extent, disk reliability is governed by the treatment it receives. Always park the hard disk before powering off, that is, run a utility to move the heads away from the data area. Move the hard disk as little as possible and try to place it on a very sturdy desk to guard against normal office collisions.

Finally, no matter what type of hard disk you select, never assume it to be inviolate. Backup time is time well spent.

END



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